PROJECT ASSIGNMENT - DESIGN OF EXPERIMENTS

Team Member

- Ismail Eyamba
- Masudul Islam

PROJECT OBJECTIVE

response variable:
- batterylife

factors:
- materialtype
- temperature

The purpose of this assignment is to design, conduct and analyse a full factorial experiment on a process. And we are going to investigate how a response variable "battery life" potentially affects two dependent variables i.e. material type and temperature. Our experiment is based on two factors and each one has three replicates.

MODEL INFORMATION

Descriptive Statistics

Dependent Variable: response

materialtype	temperature	Mean	Std. Deviation	N
M-1	15F	134.75	45.353	4
	70F	57.25	23.599	4
	125F	57.50	26.851	4
	Total	83.17	48.589	12
M-2	15F	155.75	25.617	4
	70F	119.75	12.659	4
	125F	49.50	19.261	4
	Total	108.33	49.472	12
M-3	15F	144.00	25.974	4
	70F	145.75	22.544	4
	125F	85.50	19.279	4
	Total	125.08	35.766	12
Total	15F	144.83	31.694	12
	70F	107.58	42.883	12
	125F	64.17	25.672	12
	Total	105.53	47.101	36

1. Grand Mean

Dependent Variable: response

Mean	Std. Error	95% Confidence Interval	
		Lower Bound	Upper Bound
105.528	4.331	96.642	114.414

Tests of Between-Subjects Effects

Dependent Variable: response

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[b]
Model	460316.250[a]	9	51146.250	75.748	<.001	.962	681.735	1.000
materialtype	10683.722	2	5341.861	7.911	.002	.369	15.823	.930
temperature	39118.722	2	19559.361	28.968	<.001	.682	57.935	1.000
materialtype * temperature	9613.778	4	2403.444	3.560	.019	.345	14.238	.801
Error	18230.750	27	675.213					
Total	478547.000	36						

a. R Squared = .962 (Adjusted R Squared = .949)

b. Computed using alpha = .05

In our model, we can see that the three different effects represented have an impact on battery life where the main effect temperature is statistically significant and is higher than the material type and interaction effect, where the effect size is 0.682 which and is almost double any other effect. The estimated marginal mean of our model is 105.528.

The ANOVA table gives F statistics = 7.911, p=0.002; 28.968, p<0.001 and 3.560, p=0.019, for material type, temperature and material*temperature, respectively. So, both material and temperature are needed, as well as their interaction, to explain battery life.

PAIRWISE COMPARISONS TEMPARATURE

Multiple Comparisons

Dependent Variable: response

Tukey HSD

(I) temperature	(J) temperature	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
15F	70F	37.25*	10.608	.004	10.95	63.55
	125F	80.67*	10.608	<.001	54.36	106.97
70F	15F	-37.25*	10.608	.004	-63.55	-10.95
	125F	43.42*	10.608	<.001	17.11	69.72
125F	15F	-80.67*	10.608	<.001	-106.97	-54.36
	70F	-43.42*	10.608	<.001	-69.72	-17.11

Based on observed means.
The error term is Mean Square(Error) = 675.213.

*. The mean difference is significant at the .05 level.

response

Tukey HSD[a,b]

temperature	N	Subset 1	2	3
125F	12	64.17		
70F	12		107.58	
15F	12			144.83
Sig.		1.000	1.000	1.000

Means for groups in homogeneous subsets are displayed.
Based on observed means.
The error term is Mean Square(Error) = 675.213.

a. Uses Harmonic Mean Sample Size = 12.000.

b. Alpha = .05.

In this table we see that all groups of temperature have a pairwise significant level less than 0.05 so all pairwise combinations are statistically important and have effect on battery life where some are positively and some are negetively correlated.

PAIRWISE COMPARISONS MATERIALTYPE

Multiple Comparisons

Dependent Variable: response

Tukey HSD

(I) materialtype	(J) materialtype	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
M-1	M-2	-25.17	10.608	.063	-51.47	1.14
	M-3	-41.92*	10.608	.001	-68.22	-15.61
M-2	M-1	25.17	10.608	.063	-1.14	51.47
	M-3	-16.75	10.608	.272	-43.05	9.55
M-3	M-1	41.92*	10.608	.001	15.61	68.22
	M-2	16.75	10.608	.272	-9.55	43.05

Based on observed means.
The error term is Mean Square(Error) = 675.213.

*. The mean difference is significant at the .05 level.

response

Tukey HSD[a,b]

materialtype	N	Subset 1	Subset 2
M-1	12	83.17	
M-2	12	108.33	108.33
M-3	12		125.08
Sig.		.063	.272

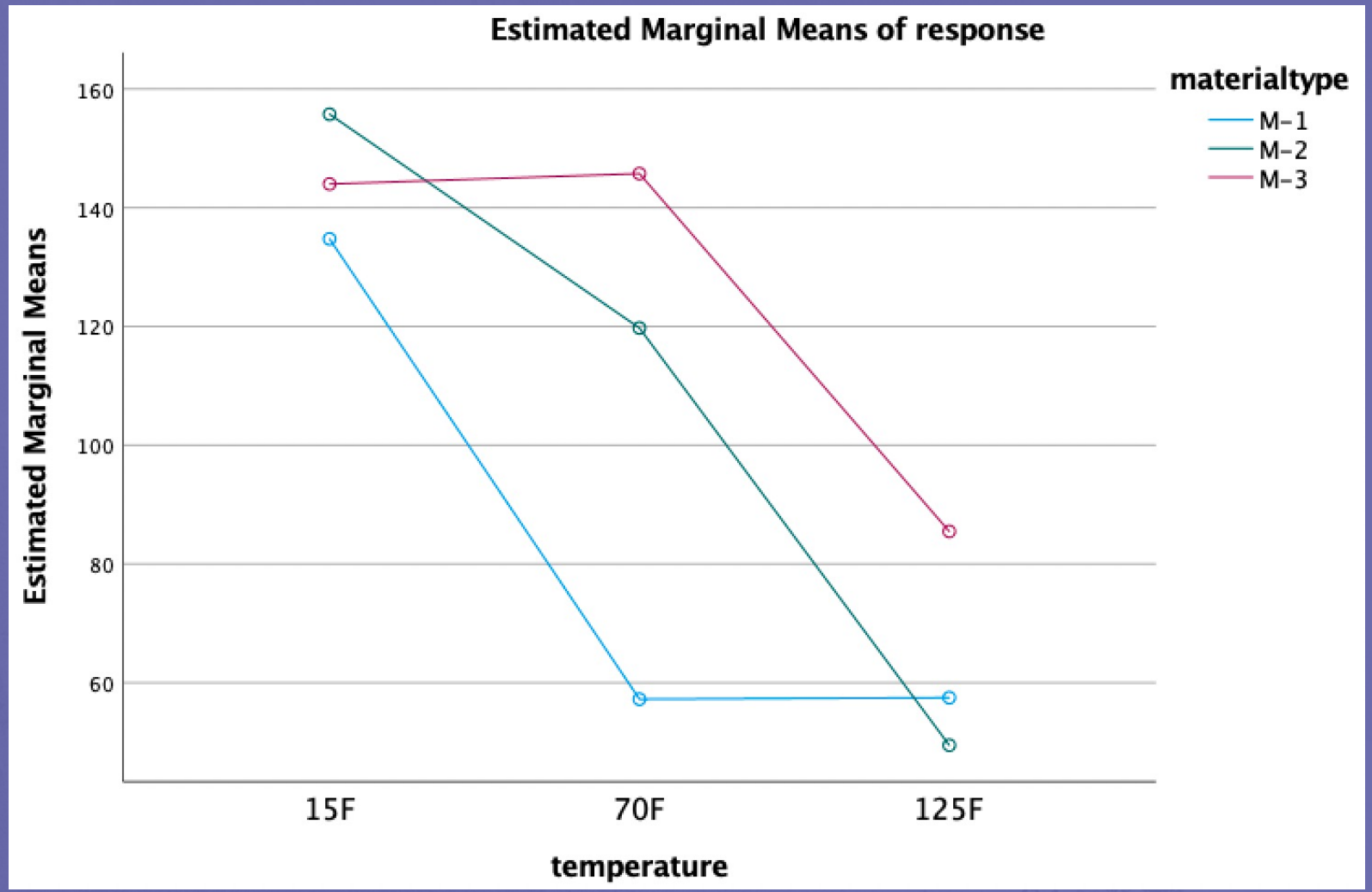
Means for groups in homogeneous subsets are displayed.
Based on observed means.
The error term is Mean Square(Error) = 675.213.

a. Uses Harmonic Mean Sample Size = 12.000.

b. Alpha = .05.

In this table we see that the 1st group of material type M-1 vs M-3 and 3rd group of material type M-3 vs M-1 have a significant level less than 0.05 so these pairwise comparisons are statistically important. Rest of the pairwise combinations don't have an effect on battery life because of a significance level higher than 0.05.

PROFILE PLOT GRAPH



From the Descriptive Statistics table, it can be seen that overall, battery life decreases with higher temperature, although battery life remains high for material type 3 at medium temperature which is 70F. Since the lines representing the three materials in the plot are not parallel, this implies there is an interaction effect between material and operating temperature. The lines would be approximately parallel if there were no interaction. So, it indicates that battery life change with temperature depends on the material, and vice versa.

MARGINAL MEANS

2. materialtype

Dependent Variable: response

materialtype	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
M-1	83.167	7.501	67.776	98.558
M-2	108.333	7.501	92.942	123.724
M-3	125.083	7.501	109.692	140.474

3. temperature

Dependent Variable: response

temperature	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
15F	144.833	7.501	129.442	160.224
70F	107.583	7.501	92.192	122.974
125F	64.167	7.501	48.776	79.558

4. materialtype * temperature

Dependent Variable: response

materialtype	temperature	Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
M-1	15F	134.750	12.992	108.092	161.408
	70F	57.250	12.992	30.592	83.908
	125F	57.500	12.992	30.842	84.158
M-2	15F	155.750	12.992	129.092	182.408
	70F	119.750	12.992	93.092	146.408
	125F	49.500	12.992	22.842	76.158
M-3	15F	144.000	12.992	117.342	170.658
	70F	145.750	12.992	119.092	172.408
	125F	85.500	12.992	58.842	112.158

The three tables of estimated marginal means give details of mean battery lives by factor, plus 95% confidence interval, giving more detail concerning the accuracy of these battery life estimates from the sample to the overall population.

CONCLUSION

By observing the results above, we can conclude that there is strong evidence that the mean battery life varies with material used and operating temperature ($p=0.002$ and $p<0.001$). The presence of interaction between material and temperature means that the way battery life changes for different materials depends on the temperature. Similarly, the way battery life changes for different temperatures depends on material. Overall, material type 3 (M-3) performs best.